Study on the Surface/Interface Modification and Manufacturing of Tungsten Carbide Mold Material

Weijia Guo[1], Tianfeng Zhou[1,*], Omer Farooq[1], Muneeb Khan[1], Xibin Wang[1]

[1] Department of Mechanical Engineering, Beijing Institute of Technology, Beijing 100081, China
Email: guo_weijia@bit.edu.cn
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Abstract
Fly eye arrays can realize light beam modulation and light spot homogenization. It has significant application requirements in high-performance optoelectronic systems, such as detection guidance, high-definition imaging, and laser weapons. Precision glass molding (PGM) is an effective method to achieve precise and efficient manufacturing of fly eye array micro-optics. The entire PGM process includes four stages: heating and insulation, high temperature and pressure, reduced pressure annealing, and cooling and demolding. It has high processing accuracy, good consistency, and high efficiency, and is suitable for mass manufacturing of micro optical devices. While it also poses higher requirements on the performance of the mold material, including high temperature resistance, high hardness, high strength, and long service life; In addition, during this process, the mold and optical lens structure are completely complementary, and the accuracy of the mold directly determines the shape accuracy of the lens, as shown in Fig 1. The selection and manufacturing of mold materials are particularly important.

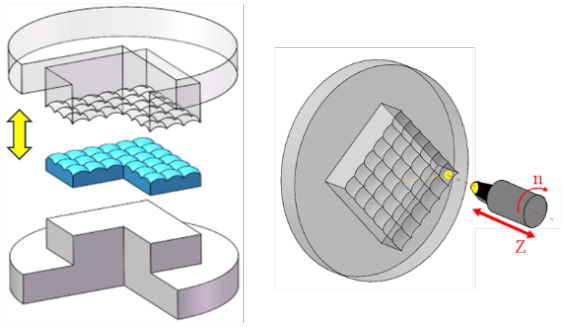

Fig 1. Schematic diagram of PGM and mold manufacturing process

Commonly used mold materials include Ni-P, WC alloy, etc. NiP has good machining performance, but Ni-P plating mold on stainless steel substrate has a short service life. WC alloy has the characteristics of high hardness, high strength, high temperature resistance, and long life, making it an ideal mold material. However, during the grinding process, the grinding wheel wears severely and there is surface/subsurface damage.

This study proposes two main directions to solve the manufacturing difficulties of WC mold materials, as shown in Fig 2: Firstly, surface modification of WC mold materials can improve the processing of molds by regulating their morphology and properties. However, there are problems such as poor consistency and difficulty in regulating surface morphology. Secondly, mold manufacturing can be achieved from the perspective of manufacturing molds with NiP platings on superhard mold substrates. While, the problems of poor adhesion between platings and substrates and short service life of molds are awaiting to be solved. It is necessary to propose methods for regulating the surface and interface properties of WC alloys, so that to achieve efficient and high-quality mold manufacturing.

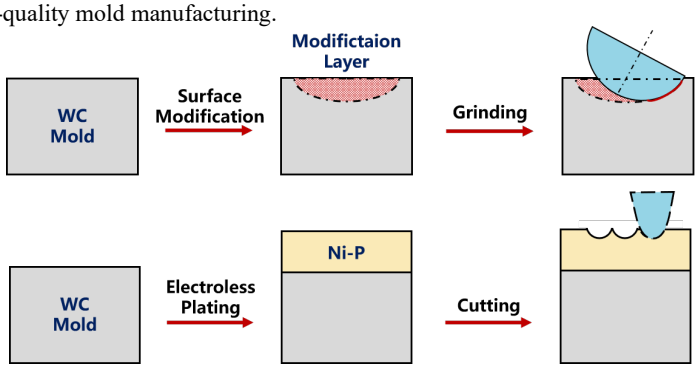

Fig 2. Two main directions to solve the WC mold manufacturing difficulties